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FIRST QUARTERLY PROGRESS REPORT
PRODUCTION ENGINEERING MEASURE FOR
HIGH RELIABILITY, FIXED, FILM, PRECISION RESISTORS

PERIOD

21 December 1962 Through 31 March 1963

CONTRACT NO. DA-36-039-AMC-01461 (E)

PLACED BY

U.S. ARMY ELECTRONICS MATERIAL AGENCY
PHILADELPHIA 8, PENNSYLVANIA

RECEIVED
1963
50 150

INTERNATIONAL RESISTANCE COMPANY
DOCUMENTED RELIABILITY DIVISION
401 NORTH BROAD STREET
PHILADELPHIA 8, PENNSYLVANIA

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FIRST QUARTERLY PROGRESS REPORT
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HIGH RELIABILITY, FIXED, FILM, PRECISION, RESISTORS

PERIOD

21 DECEMBER 1962 Through 21 March 1963

CONTRACT NUMBER DA-36-039-AMC-01461 (E)
ORDER NUMBER 21036-PP-63-81-81

The object of this contract is to establish a facility for the production of 6000 fixed, film, precision resistors per 8-hour day single shift and conform to the requirements of Minuteman Electronic Component Specification No. AC 443-01T Resistor, Fixed, High Reliability, Dated 17, September 1962, and Item Identification Document Number II D443-0147 Revision J.

Prepared

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Richard C. Wagner
Project Leader

Approved

George S. McCumber
George S. McCumber
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ABSTRACT

A project organization was formed, personnel acquired, areas of investigation designated and responsibility assigned.

Preparation of the XLT area representing 180% expansion is estimated as being 90% complete and includes the total replacement of the 602 Calculator and 101 Sorter with an IBM 1620 Computer.

Design of a subassembly machine is well under way and estimated as being 20% complete. This design will perform three subassembly operations on one piece of equipment.

A ceramic evaluation program is underway with the receipt of the Alsimag No. 531 ceramic pieces and the units are going through the manufacturing process. A Helium-Nitrogen study has been outlined and time scheduled with pro-duction for the manufacture of devices. A new Spiralling techniques investigation has started with the formulation of tests to determine the effect of mechanized handling on the metallized substrate.

PURPOSE

Although it is well established that the failure rate of the IRC XLT resistor is better than .00015% per 1000 hours, based on Minuteman use conditions, it is being produced in large part by laboratory manufacturing techniques, and its overall quality and reliability is controlled by monitoring of characteristics whose necessity has never been completely evaluated. As a result, the product is expensive and the production capacity of the existing pilot line limited.

One part of the contract is to study and evaluate those areas of the manufacturing process contributing to excessive cost, and wherever possible, eliminate or substitute alternative techniques aimed at reducing cost and increasing output.

The other part is to establish a full scale production facility for the manufacture of not less than 6,000 fixed film resistors per 8 - hour day, single shift and conform to the requirements of Minuteman Electronic Component Specification No. AC-443-018 Resistor Fixed Film High Reliability, dated 17 September 1962 and Item Identification Document No. IID 443-0147 Revision J.

NARRATIVE AND DATA

PROJECT ORGANIZATION

There are basically three engineering phases associated with the contract:

1. Reliability and Quality Control Studies.
2. Product Engineering Studies.
3. Equipment Design and Facilitation.

Upon completion, all three efforts will unite for the pilot run.

In order to accomplish these objectives most efficiently, a project organization specifically for the contract was established. (Figure 1)

Contractual matters will be the responsibility of Mr. Sava Sherr, Manager Government Operations and Mr. Morris Harris, Manager Government Contracts.

Mr. George S. McCumber, Chief Product Engineer, XLT Documented Reliability Division, will serve as Project Manager and supervise the Product Engineering Studies. Those operations pertaining to Reliability and Quality Control will be supervised by Mr. Burton Cushner, Manager Reliability and Quality Control, XLT Documented Reliability Division. Facility Design will be supervised by Mr. Robert J. Singer, Chief Mechanical Engineer, International Resistance Company.

Represented in this Project Organization are specifically two departments in the XLT Division and one from another Division. It will be necessary to include still another for the pilot run at the appropriate time.

In addition to those specific functions it is fully expected that there will be many times when other functions of the International Resistance Company will be called upon to participate.

To coordinate the efforts of all departments Mr. Richard Wagner, Senior Product Engineer, XLT Documented Reliability Division will serve as Project Leader.

IN-PROCESS CONTROL STUDIES

IBM 1620 COMPUTER REPORT

The IBM 1620 Computer installation has completely replaced the old system and has achieved its basic objective. These are:

1. Cost reduction due to increased card volume capacity.
2. More efficient operation; specifically less manual handling of cards.
3. A more precise mathematical model can be used for analysis and feedback to those people responsible for taking the necessary corrective action.
4. Self checking features of the computer provide a more reliable tool.
5. All statistical applications for analysis can now be programmed for more efficient analysis.

The old system using a 602 Calculator performed a ΔR calculation. A special punch was employed to designate those cards outside of specification limits. The cards were then sent through a 101 Statistical Sorter to obtain a distribution. This distribution was analyzed to pick out resistors which did not conform to the parent population. These were sports. The basis of the sports were on cell breaks rather than rigorous mathematical model.

The 1620 Computer System uses a program established and on file at IRC. The Computer calculates and prints out the following statistical data:

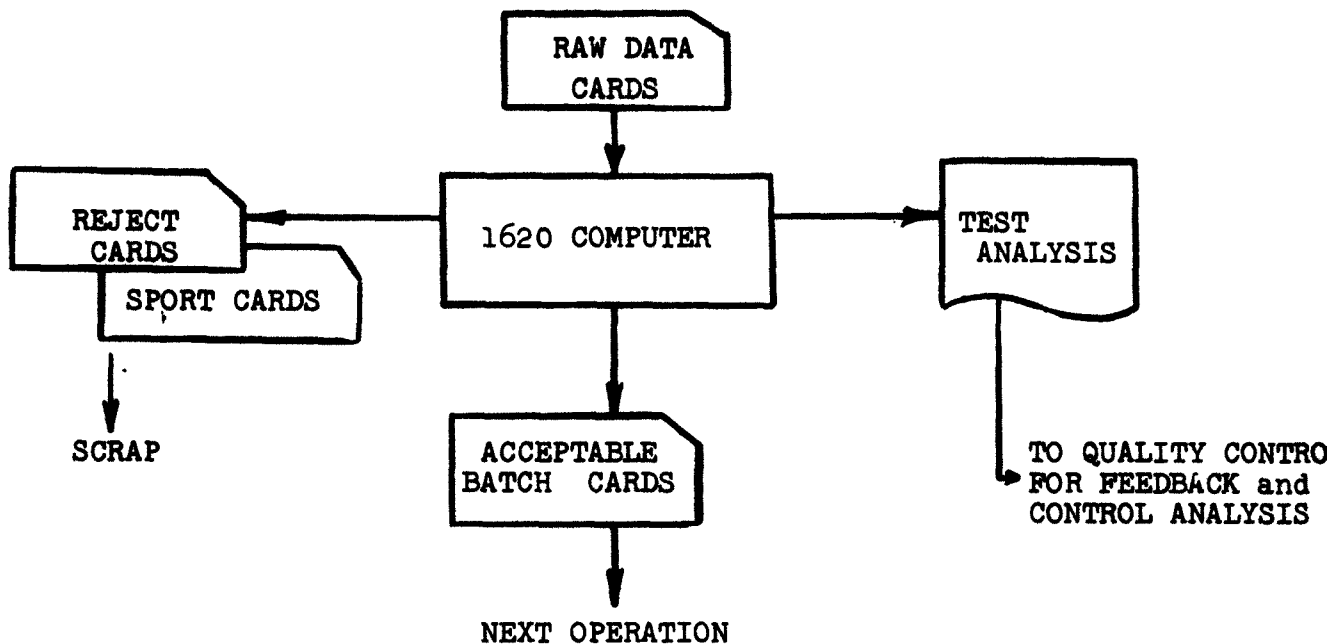
Batch number	
Number start	Number good
Algebraic average	
Maximum value	Minimum value
Upper control limit ($\bar{X} + 3\sigma$)	Lower control limit ($\bar{X} - 3\sigma$)
Span (max. value - min. value)	
Std. deviation (σ)	Variance (σ^2)
Average deviation	
Skewness	Kurtosis
Short *	Open *
Over spec	Under spec

Sports (Technique used is per F. Preshen article in IQC Jan.1957)

Samples of the computer output for each of the three stations are shown in Figs. 2 and 3. Also attached is the process flow through the computer of each of the three cycles and final cards.

* These are primarily rejects replaced with lower or higher resistance values.

CYCLE I CALCULATIONS and CARD FLOW (SEAL)



1620 Operation

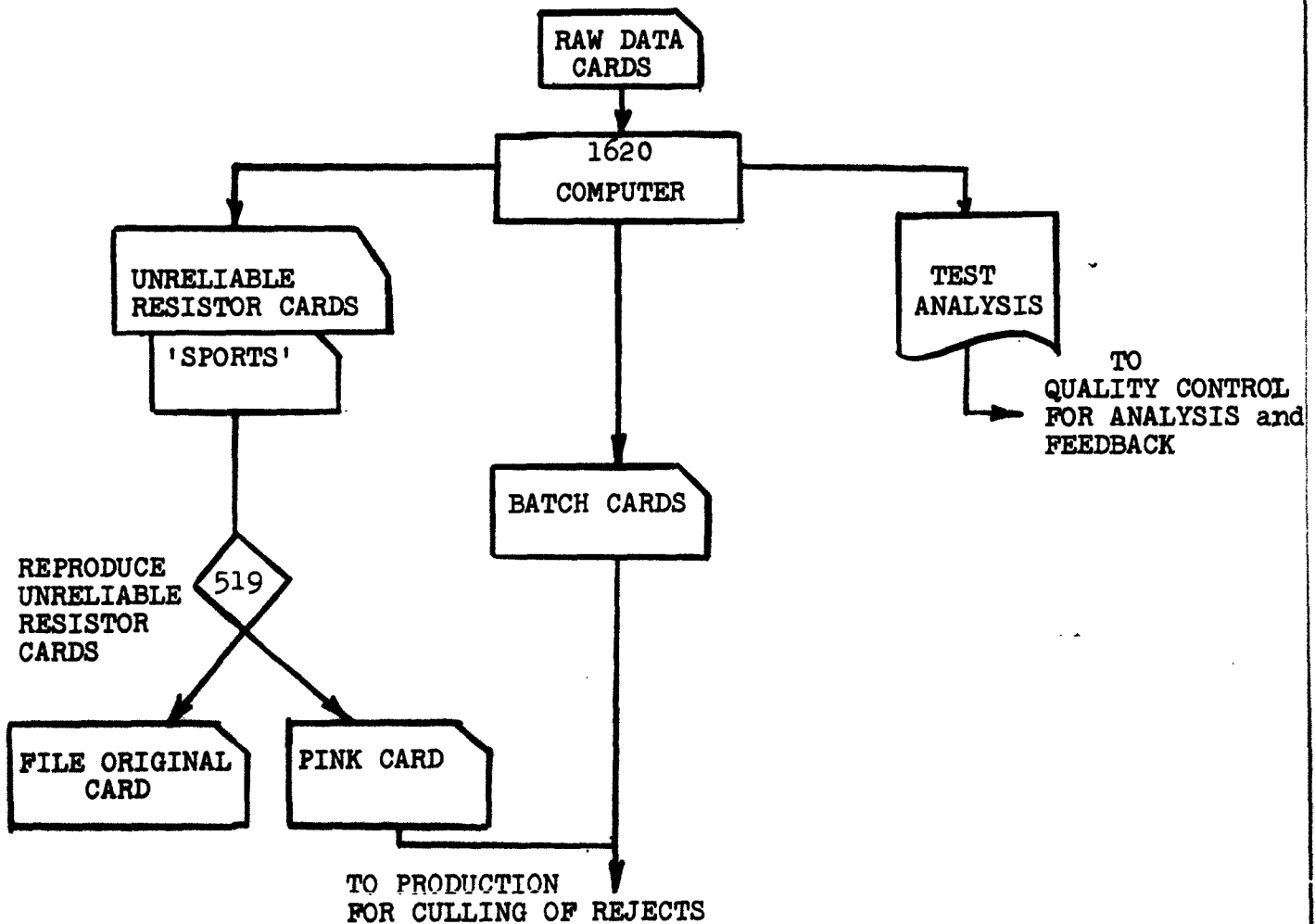
1. Selects rejects for ΔR over and under a predetermined span.
2. Calculates and prints out post seal and ΔR distributions.
3. Computes all significant statistical information.
4. Identifies all rejects and sports and withdraws these from the parent batch.
5. Computes a ratio of total good to total input and prints each of these numbers.

CYCLE II CALCULATIONS and CARD FLOW (SCREEN TEST)

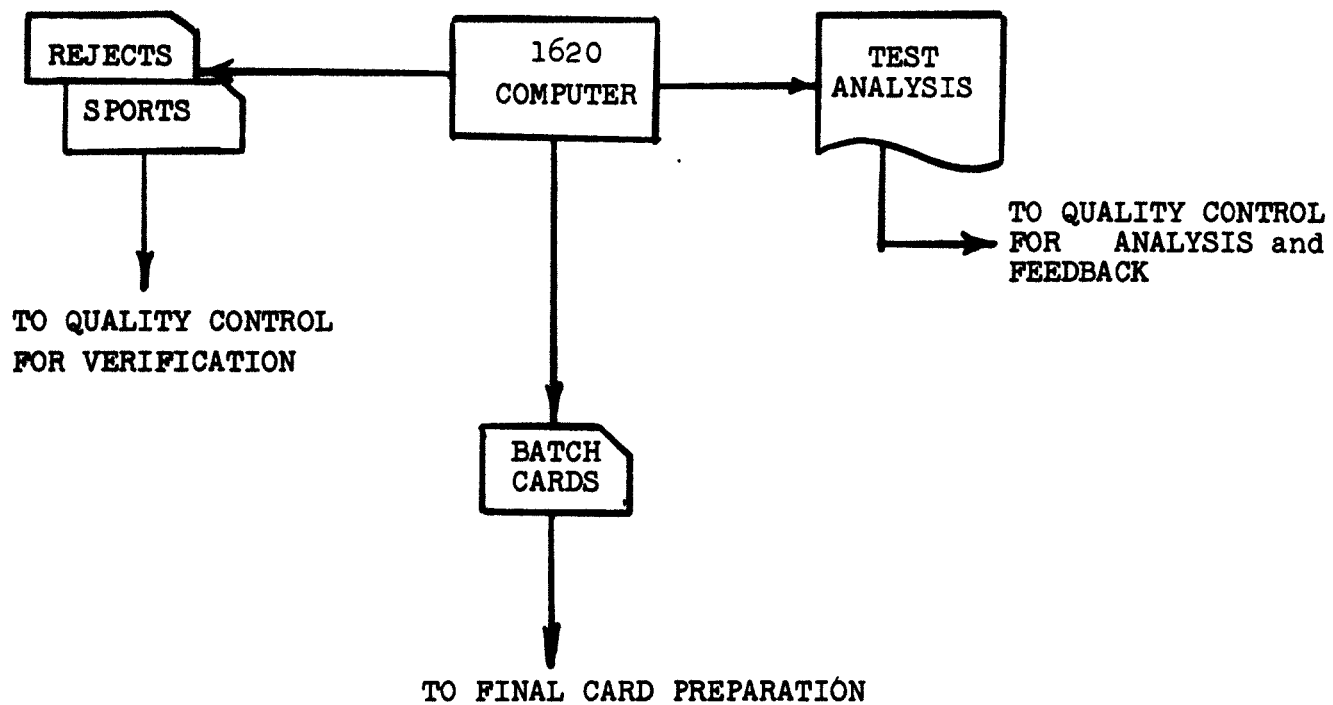
Five screen tests are performed and punched on an IBM card. These cards are fed into the computer for analysis.

The screen tests are as follows:

1. 175°C cure for 1 hour.
2. Short time overload.
3. Temperature Coefficient -65°C.
4. Temperature Coefficient +145°C.
5. Set (comparison of resistance before T.C. to after T.C.)



CYCLE III CALCULATIONS and CARD FLOW (BURN IN)



The following programs are available at IRC for use with the 1620 Computer. These will result in better and more powerful statistical analysis of data. They are as follows:

1. 1620 Regression Analysis Program.
2. Multiple Linear Regression Analysis Program.
3. Distribution Statistics.
4. Generalized Analysis of Variance.
5. Correlation Analysis (up to 40 by 40).
6. Frequency Distribution.
7. Mann Whitney Test.
8. Analysis of Covariance.
9. Test for Normality.
10. Homogeneity of Variance.
11. Multiple Range Test of Mean Differences.
12. 2 X 2 Contingency Tables.
13. Chi Square Goodness of Fit.
14. Probit Analysis.
15. One Pass Analysis of Variance.
- 16.. Split Plot Analysis of Variance.

IN-PROCESS CONTROL STUDIES
REEVALUATION OF IN-PROCESS INSPECTION REJECT CATEGORIES

A program for the reevaluation of In-Process Inspection categories was started and has progressed into the final planning stage. This program is being formulated on the basis of reviewing all potential inspection areas, selecting those which have the greatest potential of contribution and assigning them priority status.

Another program of this phase is to reduce the overall process time by reducing the burn-in time without impairing the reliability of the end product. This program was started by collecting data at the end of one week burn-in for comparison with the results of the full two week schedule. The accumulation of this data is not complete at this time.

FACILITIES PROGRAM
SUBASSEMBLY MACHINE

It was originally planned to provide an individual machine for each of the three operations: (Preform-Lead Assembly, Subassembly and Pull Test) comprising the complete sub-assembly procedure. Following the initial studies, however, it was found that the three operations can be ideally incorporated into one machine. This is the current concept and the machine design is proceeding on that basis.

Figure 4 shows a conceptual drawing of the finished machine. It will incorporate separate feed systems for feeding the leads, frits and substrates to two counter rotating turrets for the positive manipulation of the component while in that indexing position where the subassembly is actually effected. All of the machine functions will be positively coupled and driven through a synchronizing transmission system.

Lay-out of the two counter rotating turrets is well in progress and is estimated as about 20% complete. The design work was also started during this quarterly report period on the synchronizing transmission system and is progressing simultaneously with the feed system and turret head design.

FACILITIES PROGRAM
PREPARATION AND EXPANSION OF XLT AREA

Associated with the subject contract and the first step toward achieving a Manufacturing Facility capable of producing at the rate specified (6,000/8 hr. single shift) was a major expansion of the manufacturing area. This effort is estimated as being approximately 90% complete. An addition of 20,000 square feet was added to the XLT manufacturing area. This new area is located on the sixth floor of the northern wing in the building at 401 North Broad Street and includes office space for all the managerial, technical and overhead functions associated with the production line as well as all production operations which are not specified to be carried out in the Ultra Clean room. It should be noted that the Radiflo equipment was not relocated from its third floor site as this would have been extremely costly and its present location does not adversely affect the production operation. A lay-out of this completely new modernized area is shown in Figure 5.

A picture of the general office area containing the Functions of Marketing, Product Engineering, Reliability and Quality Control is shown in Figure 6. General sections of the manufacturing area, namely, Inspection, Testing and Lead Preparation are shown in Figures 7, 8, and 9 respectively.

Also shown are the specific functions of Gross Leak Test, Figure 10; unit marking machine which automatically marks each resistor with individual identification and will ultimately replace applying labels by hand, Figure 11; new Load Life Room, Figure 12; and the IBM 1620 Computer Console, Figure 13.

The Ultra Clean room on the third floor of the same building was expanded into the area vacated by those operations moved to the sixth floor. The floor plan of this expanded area is shown in Figure 14.

The area expansion representing 180% increase in space has been accompanied by the addition of new equipment and additional operating stations.

Figure 15 is a list of the operations which were increased in capacity.

PRODUCT ENGINEERING STUDIES

PRODUCT ENGINEERING STUDIES

CERAMIC EVALUATION

During the original development phases of the XLT resistor, the use of alkaline earth substrates was questioned for two basic reasons. First, the coefficient of expansion of the alkaline earth material compared to the glass case of the resistor did not match, and it was anticipated that a serious problem would result in preserving the integrity of the glass seal under temperature stress. Secondly, since the element was enclosed in a glass envelope of extremely low heat dissipation, it was felt that a ceramic of better thermal conductive properties would be needed. Consequently, a high purity alumina ceramic was selected as the XLT substrate.

It is now known that in spite of its theoretical performance advantages, high purity alumina is difficult to produce to a constant quality level and in spite of extensive efforts to improve the substrate yields, no significant progress has been achieved.

Another disadvantage in the use of high alumina ceramic is its extreme hardness. This causes rapid wear-out of the diamond wheels used for the spiralling operation. Skips in spiralling are frequent and this results in rejection of units and adds to product cost.

Ironically, the final design of the XLT, through incorporation of the bellows lead construction, has eliminated any problem of thermal mismatch between the ceramic substrate and glass case so that the primary theoretical reason for the use of alumina ceramics no longer exists. In addition, less effort is required to control product uniformity as the alkaline earth ceramics are currently available with good surface finishes; freedom from imperfections such as pits, voids, and other defects; and are reasonably uniform between batches, particularly when compared to the high purity alumina ceramic body.

It is now necessary to establish that the alkaline earth ceramic will not adversely affect the established reliability of the XLT.

A program was established during the First Quarterly Report Period for this purpose. The alkaline earth ceramic will be evaluated by simply introducing it into the existing manufacturing process and thoroughly evaluating the end product against a batch of controls. The program was initiated on February 1, 1963 with an order to American Lava Company for 25,000 pieces of Alsimag No. 531 (alkaline earth) ceramic substrates (Figure 16). Delivery was made on March 1, 1963 and after a quick visual examination which did not reveal

any gross obvious defects, were immediately started through the manufacturing process.

In addition, to those pieces currently being processed, another sample group of substrates have been submitted for incoming inspection; however, no report on any findings has been made so far. It is planned to process units for each of the following resistance ranges: 10 Ω , 50 Ω , 100 Ω , 200 Ω , 500 Ω , and 700 Ω .

Figure 17 shows the results of three evaporations made to date.

Each evaporation is carried out with a control group of Type 614 ceramic substrates. It can be seen that the measured resistance value of evaporated substrates is considerably different on each type of substrate even though both were processed side by side at the same time. This confirms previous knowledge that the 531 body has a smoother surface than the 614 type ceramic. All of these units are currently at the heat treating process.

PRODUCT ENGINEERING STUDIES
INVESTIGATION OF NEW SPIRALLING TECHNIQUES

As the XLT manufacturing process is now specified, the Spiralling operation which adjusts toward the desired resistance value follows the subassembly operation which assembles the leads to the ceramic substrate.

Spiralling the resistor in this subassembled condition offers a series of production disadvantages along with the advantage of providing ease in targeting to the final resistance value.

1. The resistor element prior to Spiralling comprises a stock station as this is the first step in the processing of orders to a specific value through the plant. The resistor subassembly with leads poses a storage problem due to its configuration.
2. A high incidence of bent leads develops in storage, handling, and during the Spiralling operation.
3. Because of the high cost of the subassembled unit, the value of the storage inventory is greater, tending to reduce the amount of bin stock consistent with good inventory control.
4. Spiralling with leads attached introduces mechanical problems requiring special handling care in the operation. Automatic handling in this form is awkward, clumsy and automatic feeding very difficult.

For these reasons and to promote compatibility for automation, an initial program was formulated on February 25, 1963 to determine the effect of mechanized handling methods on both the metallized substrate before and after Spiralling. The same automatic feed systems under consideration for the automatic equipment are being used in the test. The mechanism is a Syntron Feeder. Both high and low range resistors are being used for the purpose of magnifying any effects which might result.

Resistance Readings will be made at timed intervals during feeding operation, to determine the effect of time in feeder vs. variation. The evaporated substrates have been selected but have not yet been processed through the Syntron feeding operation.

An outline of the initial test (E.E. 400) is given in Figure 18.

PRODUCT ENGINEERING STUDIES

HELIUM - NITROGEN STUDY

At the present time, helium gas is used as the internal atmosphere of the XLT resistor. Helium fulfilled the original requirements of being inert so that no interaction between the atmosphere and the film was possible, and could be introduced at slightly below atmospheric pressure. Another consideration given to the original choice of helium was the possibility of utilizing the internal ambient gas as a means of checking the integrity of the glass seal through helium detection methods; however, due to subsequent developments, the helium leak detection methods were discarded and Radiflo testing substituted.

Another portion of this contract is concerned with automation of the glass sealing operation. Before the design of this machine can be started, it is desired to find out if another gas such as high purity dry nitrogen can be substituted for the helium. If this is possible the entire glass sealing operation will be enclosed in a controlled chamber filled with the same gas as the internal atmosphere of the resistor. Helium cannot be used because it will not support the arc required in the arc sealing process. Not only will a study of nitrogen provide information required prior to the design of the glass sealing machine but it will reduce the cost by substituting nitrogen for helium.

A program to study the use of nitrogen has been formulated and is scheduled to begin April 17, 1963. The program is identified as EE 401 and has the title 'Helium to Nitrogen Initial Evaluation'. The items of particular interest during the manufacture of the resistors are: 1) Effect on the glass seal if any, 2) Chemical effect, if any, on the resistor as a result of heat generated during the sealing operation, 3) Chemical effect, if any, on the resistor due to subsequent heating operations during the manufacturing process and 4) Effect on the resistor, if any, at Screen Testing and Burn-In. A high and low resistance range has been selected to magnify any effects resulting from the nitrogen ambient.

At the completion of manufacture, a matrix evaluation is scheduled using accelerated techniques. Resistors with controls will be subjected to 1, 3, and 5 times overload testing both at 25°C and 125°C. This evaluation is scheduled to start May 6, 1963.

An outline of EE 401 'Helium to Nitrogen Conversion Initial Evaluation' is shown on Figure 19.

CONCLUSIONS

The 1620 Computer has successfully replaced the 602 Calculator and 101 Sorter Systems and thereby reduced the cost of data handling.

Other programs are proceeding on schedule.

About 90% of the additional working areas has been set-up and placed in operation.

PROGRAM FOR NEXT INTERVAL

1. Design of the Glass Sealing and Termination Inspection machine will begin.
2. The In-Process Control studies of rejection categories will begin.
3. The Product Engineering programs will continue.
4. The design of the subassembly machine will continue.

PUBLICATIONS AND REPORTS

There were no publications or conferences during the First Quarterly Report Period.

IDENTIFICATION OF TECHNICAL PERSONNEL

MAN HOURS OF WORK PERFORMED
INCEPTION THROUGH 10 MARCH 1963

<u>DEPARTMENT</u>	<u>HOURS</u>
Reliability and Quality Control	
W. Miller	67.5
E. Driscoll	75.0
Facilities Engineering	
R. Singer	20.5
W. Douglass	90.0
L. Lolli	121.5
A. Nekludov	2.0
Product Engineering	
C. Stiles	6.0
G. McCumber	3.0
Total	385.5

ROBERT CROSS

SR. QUALITY CONTROL ENGINEER

Mr. Cross is a graduate of Penn State University and has done graduate work in applied mathematical statistics at Rutgers University and the Western Electric Graduate Engineer Training School.

Before coming to International Resistance Company in 1962, Mr. Cross had six years of technical experience with Bendix Aviation Corporation, Redstone Arsenal, and Western Electric Company. He is a member of the American Institute of Industrial Engineers, and the American Society for Quality Control.

BURTON CUSHNER
MANAGER, RELIABILITY AND QUALITY CONTROL
DOCUMENTED RELIABILITY DIVISION

Mr. Cushner received his B.S. Degree in Mathematics from Pennsylvania State University in 1952. He received an M.B.S. Degree in Applied Statistics from Villanova University in 1957.

Mr. Cushner has been employed with the International Resistance Company for eleven years and has been managing a Quality Control Department for the last four years.

He is a member of P.G.R.Q.C. of I.R.E; the American Society for Quality Control and the American Statistical Association. He is the author of several papers on quality control and has delivered many lectures to professional and management groups on this subject.

EDWARD DRISCOLL
JR. QUALITY CONTROL ENGINEER

Mr. Driscoll is presently attending La Salle College Evening Division pursuing a degree in Electronic Physics, having previously attended the Radar Repair School U.S. Army, Fort Monmouth, New Jersey

He has eleven years industrial experience related to Quality Control activities with ITE Circuit Breaker Company, Philadelphia.

Mr. Driscoll has recently joined International Resistance Company and is assigned to the XLT Documented Reliability Division as a Jr. Quality Control Engineer.

WALTER H. DOUGLASS
SR. MECHANICAL ENGINEER

Mr. Douglass is a graduate of Dobbins Vocational School and of the Technical Representative Division School at Philco Corporation. He has had twenty-five years of industrial experience in a technical and engineering capacity with A. B. Landis and the Philco Corporation. Since 1951, he has been a mechanical and manufacturing engineer at International Resistance Company.

Mr. Douglass has been responsible for the development of key mechanical production equipments in IRC production lines. He also holds the patents on the bellows lead construction currently a part of the XLT resistor.

MORRIS HARRIS
MANAGER OF GOVERNMENT CONTRACTS

Mr. Harris is a graduate of Fordham University with an L.L.B. degree, and has taken courses in government contracts at Columbia University. He was admitted to the New Jersey Bar in 1935.

After twelve years of private practice, Mr. Harris joined the Allen B. DuMont Laboratories as Assistant General Counsel. Since 1959 he has been Manager of Government Contracts Administration for International Resistance Company. He has also served as an instructor at Fairleigh Dickinson University.

Mr. Harris was president of the Defense Contract Management Association of Delaware Valley, is a member of the Legal and Program Committee of Temple University Government Contract Association, and is a member of the Government Contract Provisioning Committee of the Electronic Industries Association.

LAWRENCE LOLLI
MECHANICAL ENGINEER

Mr. Lolli is a graduate of the Spring Garden Institute and received an M. E. in Machine Design from Drexel Institute of Technology. Prior to his association with International Resistance Company in 1960, he had been with the Pennsylvania Railroad and with Yale and Towne as a mechanical designer and engineer.

His duties at International Resistance Company include design and development of automatic production equipment. He has been associated with the XLT program in all its machine design phases.

GEORGE S. McCUMBER
CHIEF PRODUCT ENGINEER
DOCUMENTED RELIABILITY DIVISION

Mr. McCumber received his B.E.E. degree from Clarkson College of Technology in 1948.

Prior to his coming to International Resistance Company in 1962, he had fourteen years of experience in Product Engineering work. He was Chief Engineer for Sylvania Electric Products, Inc. for three years in the manufacture of television picture tubes. He was Chief Engineer for Philco Corporation for five years in the manufacture of transistors and other semi-conductor products.

He is currently Chief Product Engineer of the Documented Reliability (XLT) Division and is the Project Manager of the subject contract.

He received a commission as 2nd Lieutenant in the Signal Corps Branch of the Armed Forces of the United States in 1948. He held the Reserve Commission for five years.

WALTER MILLER
SR. RELIABILITY TECHNICIAN

Mr. Miller is presently attending Temple University Evening school where he is a Junior and a candidate for Bachelor of Arts Degree directed toward Major in Chemistry.

He has two years of industrial experience with the XLT Division of International Resistance Company as a Sr. Reliability Technician and one year experience with the Glass and Ceramics Research Division

ALEXANDER NEKLUDOV

MECHANICAL DESIGN SUPERVISOR

Mr. Nekludov is a graduate of Toganrog Technical College and has a BME degree from the University of Novocherkask, U.S.S.R. Prior to his arrival in the United States in 1949, he had eighteen years of design and engineering experience in precision instruments and automatic equipment.

After two years of machine shop development work at the University of Pennsylvania, Mr. Nekludov joined IRC in 1951. He is an expert in high speed automatic equipment and is a citizen of the United States.

PAUL ROGERS
SR. RELIABILITY ENGINEER

Mr. Rogers is a graduate of the University of Scranton and has done graduate work in mathematics and applied mathematical statistics at Villanova University.

Before joining International Resistance Company in 1961, he had six years of industrial experience at El-Tronics, Sperry and Philco. He is currently with the Documented Reliability (XLT) Division of International Resistance Company.

SAVA I. SHERR

MANAGER OF GOVERNMENT OPERATIONS

Mr. Sherr is a graduate of the Cooper Union Night School of Engineering, a registered professional engineer, and has done graduate work at the Towne School of Engineering, University of Pennsylvania. He has had twenty-five years of industrial experience, and has been associated in an engineering capacity with such firms as Carl L. Norden, Sperry Gyroscope and Otis Elevator Company. He has also been a member of the Engineering faculty of Pratt Institute. He was president of Stanley Industries, Inc., and has been with International Resistance Company in an executive capacity since 1956.

Mr. Sherr is active in the Institute of Radio Engineers, Armed Forces Communications Electronics Association, and Electronic Industries Association. He is chairman of the Military Test Equipment and Procedures (M-3) Committee of Electronic Industries Association, is a member of the Military Equipment Panel of the Military Components Engineering Coordination (M-1) Committee. He is a holder of several patents.

ROBERT J. SINGER

CHIEF MECHANICAL ENGINEER

Mr. Singer received a BS and MS degree at the Drexel Institute of Technology. He has had over twenty years of industrial experience in design and development of high speed production equipment.

Mr. Singer has been with International Resistance Company since 1951, and has the overall responsibility for the design and development of all production equipment and facilities.

CHARLES J. STILES

SR. PRODUCT ENGINEER

Mr. Stiles is a graduate of Drexel Evening College with a BSEE degree. He has been with International Resistance Company since 1954, and has done product engineering work on metal film resistors, pressure transducers, and transformers.

Mr. Stiles is currently assigned to the XLT operation as Sr. Product Engineer.

RICHARD C. WAGNER
SR. PRODUCT ENGINEER

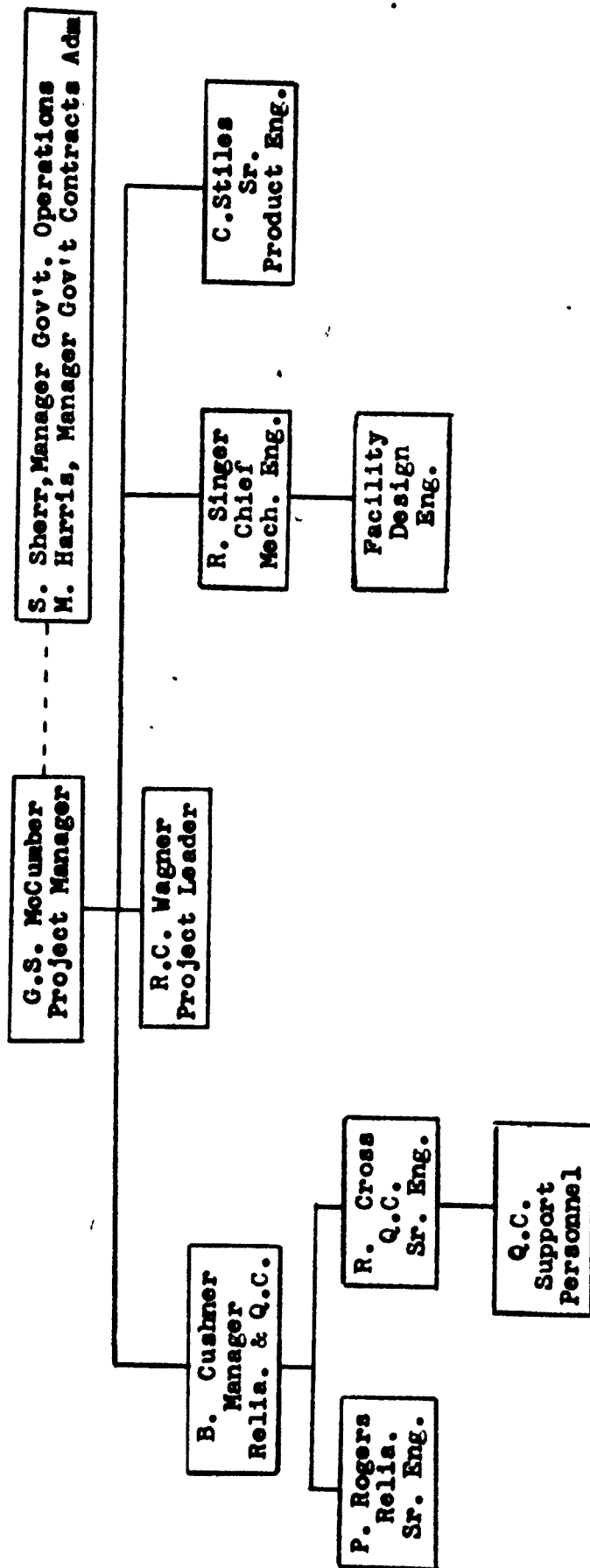
Mr. Wagner is a graduate of Lafayette College with a B. A. Degree in Chemistry.

Before recently joining International Resistance Company, he had nine years industrial experience with Philco Corporation in design, development and production of Semiconductor equipment and components.

He is currently associated with the Documented Reliability (XLT) Division of International Resistance Company and has the overall responsibility for contract coordination.

Mr. Wagner is a member of the Institute of Electrical and Electronic Engineers.

APPENDIX



PROJECT ORGANIZATION

FIGURE 1

Data Analysis

Cycle I

BATCH NO. 11055

NO. START 00488

NO. GOOD 00427

DELTA R

X BAR	4798594801
X MAX	3000000000
X MIN	2000000000
UCL	1946186200
LCL	9864674001
SPAN	5000000000
STD. DEV.	3665817001
VARIANCE	1343821502
AVG. DEV.	2147027001
SKEWNESS	1104370801
KURTOSIS	2046737902
000,S	041
999,S	003
OVER SPEC.	000
UNDER SPEC.	001
SPORTS	011

POST SEAL	
OVER SPEC.	002
UNDER SPEC.	003

Figure 2

Data Analysis

Cycle II

BATCH NO. 03036
NO. START 00240

NO. GOOD 00235

175 CURE

S.T.O.L.

TCL0

TCHI

SET

X BAR	1052340400	6382978703	9974468001	1975319100	5829787202
X MAX	4000000001	2000000001	1500000000	2300000000	0000000059
X MIN	1300000000	1000000001	4000000001	1400000000	3000000001
UCL	5855844001	1986124401	1778350000	2701713300	1663565901
LCL	1519096400	1858465001	2165435601	1248924900	2849523301
SPAN	9000000001	3000000001	1100000000	9000000001	3000000001
STD. DEV.	1166890001	4805736902	1952258101	1815985501	5666361902
VARIANCE	1361632403	2309510804	3811311903	3297303403	3210765804
AVG. DEV.	9076098202	2420206702	1529863701	1435189701	5176431002
SKEWNESS	3668014300	7086429500	2700157100	3861610500	6528650700
KURTOSIS	5934412801	4995248501	2825082101	2946144401	3149783901
000,S	000	000	000	000	001
999,S	001	000	000	000	000
OVER SPEC.	000	000	000	000	000
UNDER SPEC.	000	000	000	000	000
SPORTS	000	000	001	000	002
25 DEG					
OVER SPEC.	000				
UNDER SPEC.	000				

Figure 2a

Data Analysis

Cycle III

SPORTS
POS

BATCH NO. 10051
NO. START 00161

NO. GOOD 00161

BURN IN

X BAR	2341614901
X MAX	1000000001
X MIN	8000000001
UCL	2071363501
LCL	6754593301
SPAN	9000000001
STD. DEV.	1470992801
VARIANCE	3163820003
AVG. DEV.	1139308901
SKEWNESS	3139872300
KURTOSIS	3621023601
000,S	000
999,S	000
OVER SPEC.	000
UNDER SPEC.	000
SPORTS	000

R 1	
OVER SPEC.	000
UNDER SPEC.	000

Figure 3

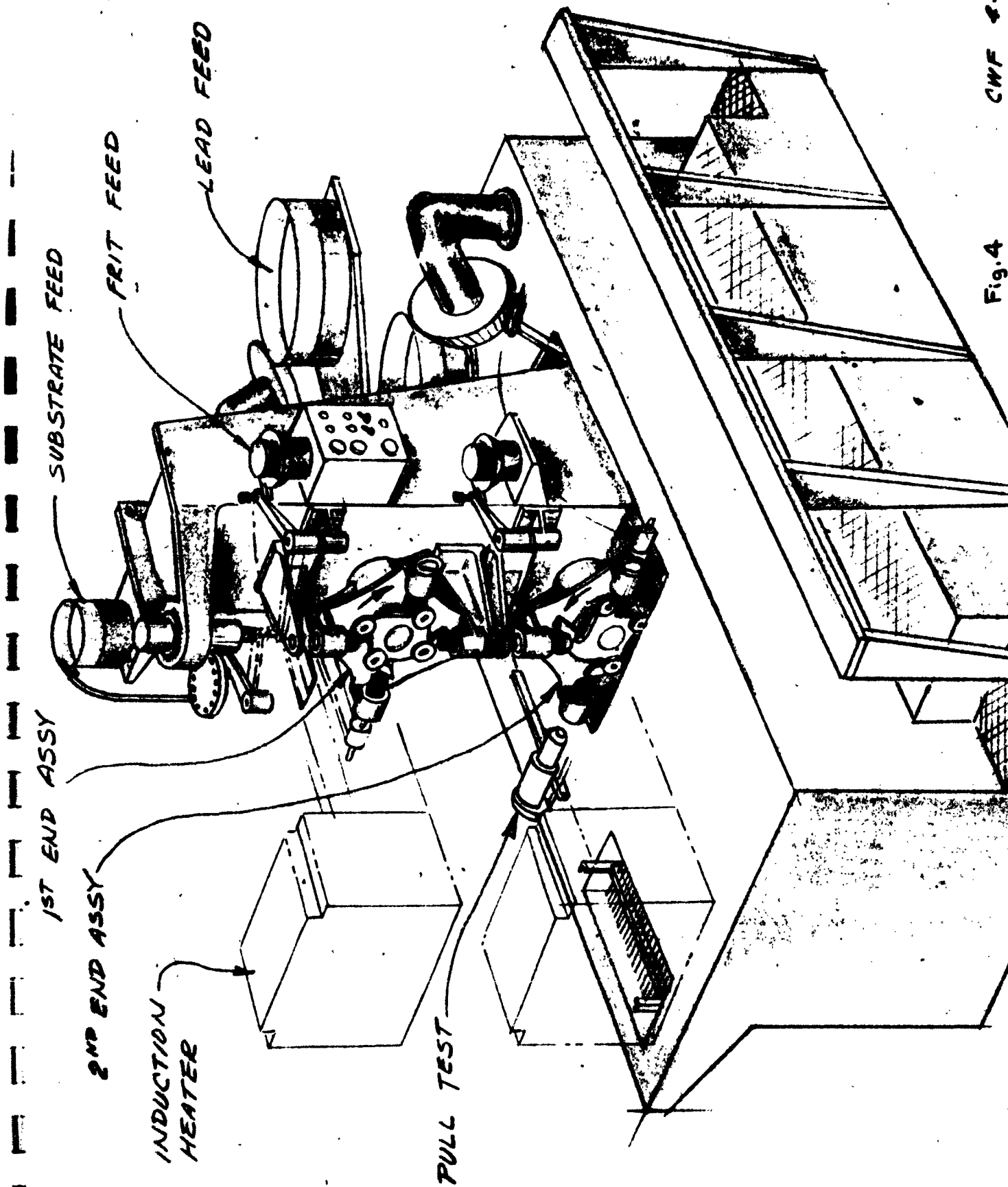
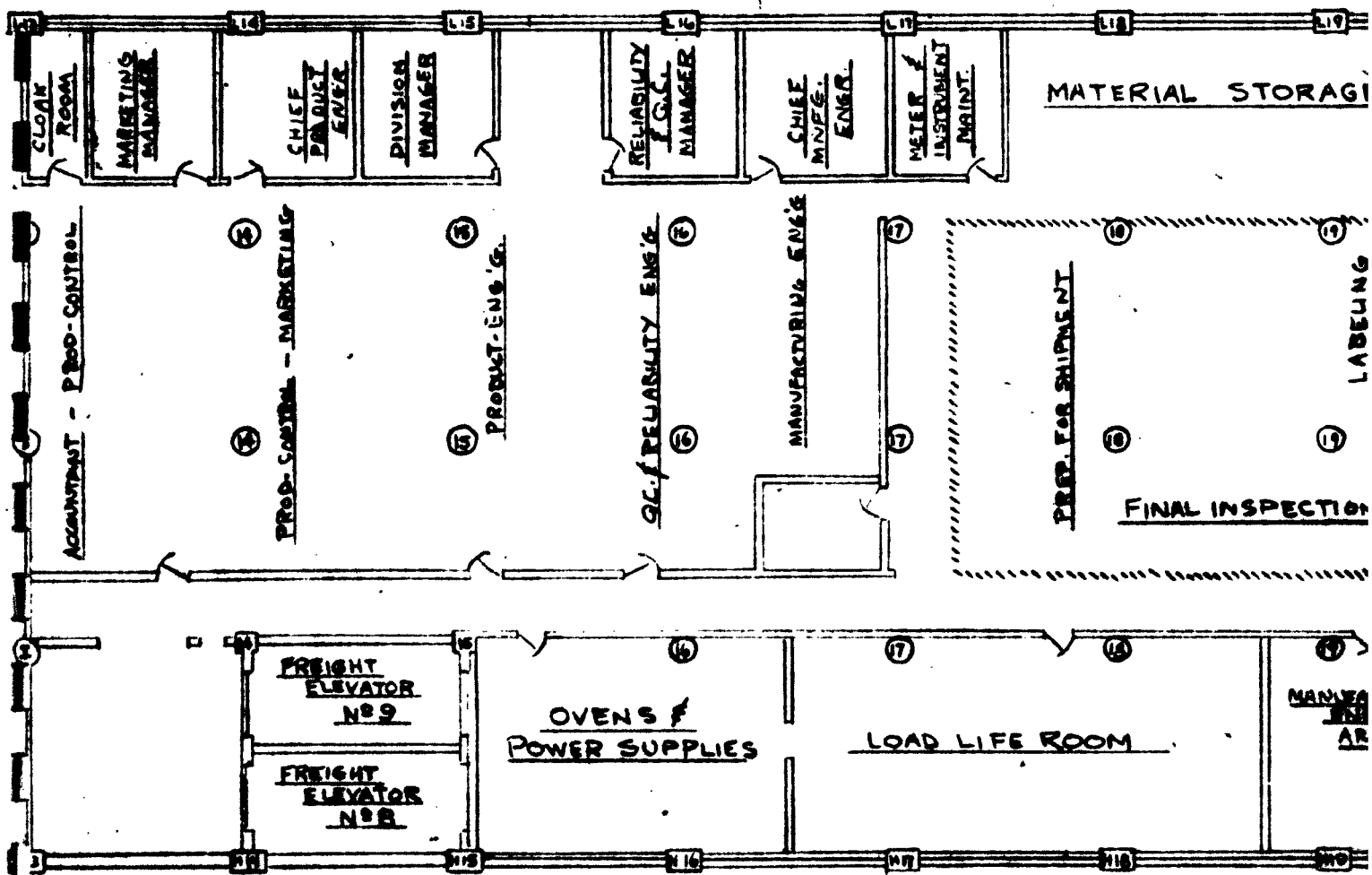
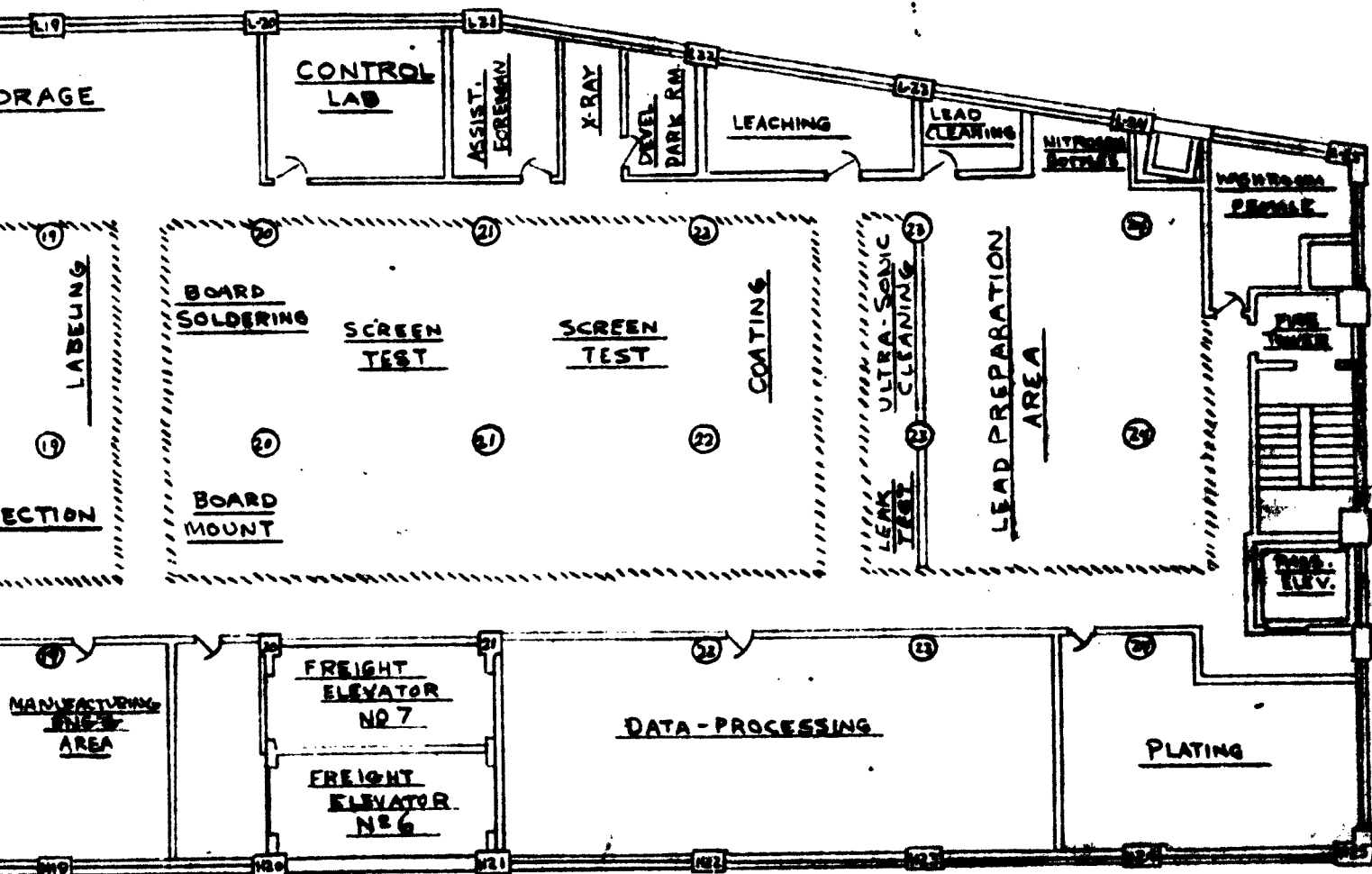


Fig.4



Floor Plan of XLT Area

Fig. 5



T Area





Figure 6
General Office Area - Documented Reliability Division



Figure 7
Final Inspection Area



Figure 8
Screen Test Area



Figure 9
Lead Preparation Area



Figure 10
Gross Leak Test Operation

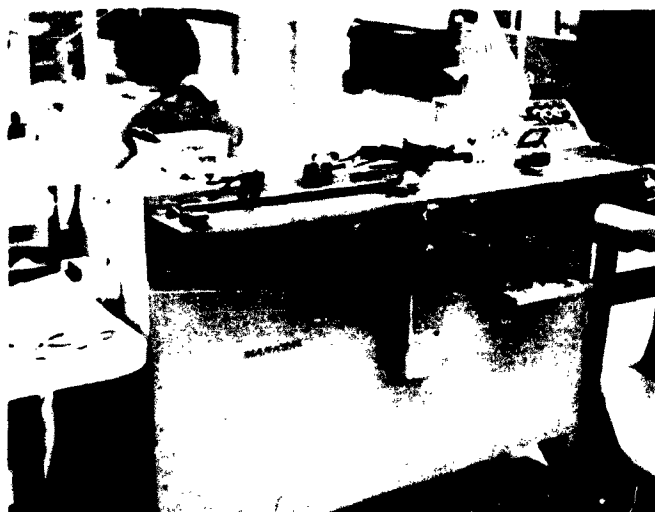


Figure 11
Marking Machine



Figure 12
Load Life Room



Figure 13
IBM 1620 Computer

FLOOR PLAN OF THE ULTRA-CLEAN ROOM

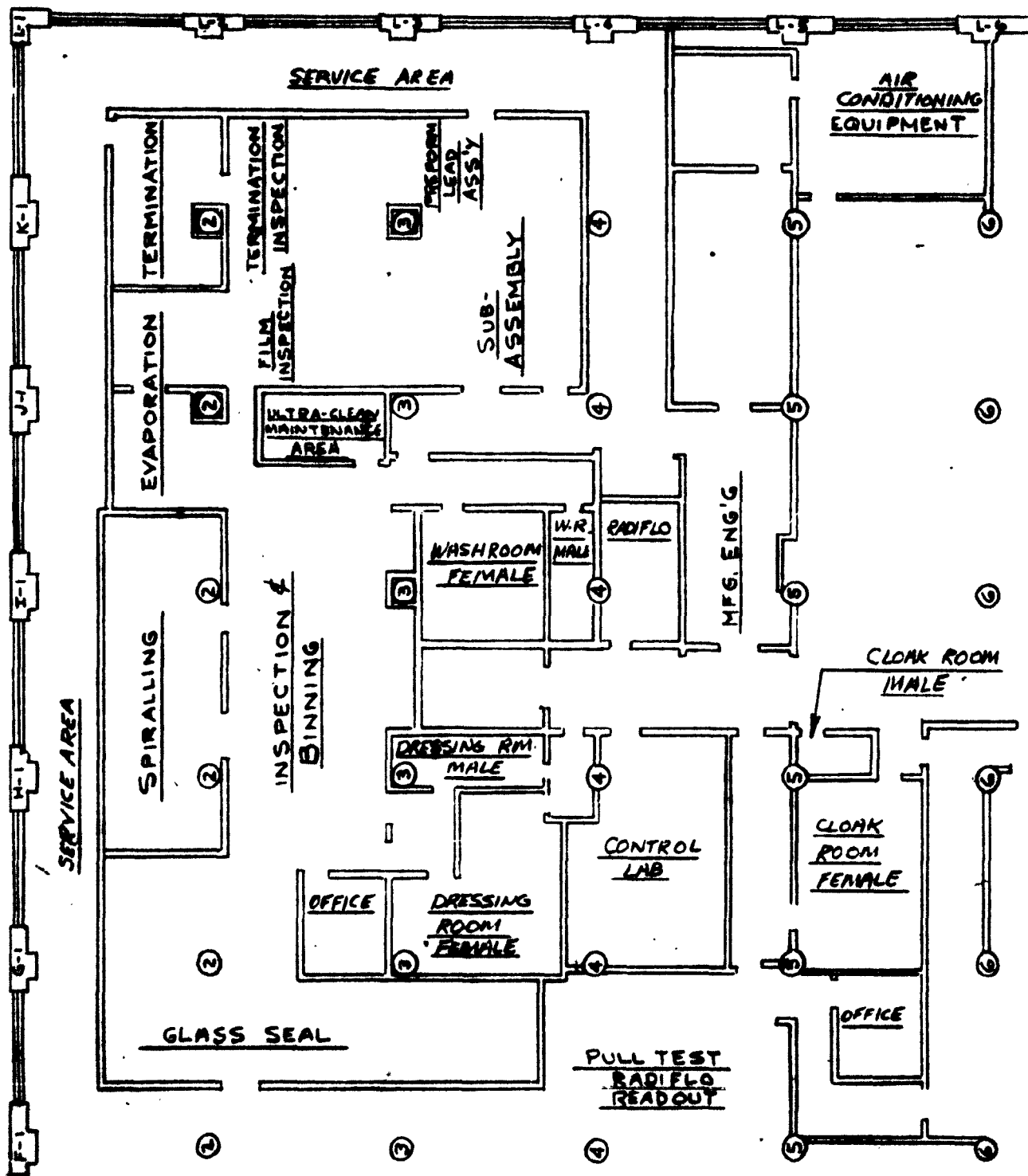


Fig 14

ADDITIONAL OPERATIONS ADDED TO EXPANDED AREA

<u>OPERATION</u>	<u>PREVIOUS STATIONS</u>	<u>STATIONS ADDED</u>	<u>PRESENT NUMBER</u>
Termination	1	1	2
Evaporation	1	1	2
Film Inspection	1	1	2
Batch Evaluation	1	1	2
Digital Meters and IBM Equipment	10	4	14
Gross Leak Test	1	1	2
Consolidation Stations	2	2	4
Plating Line	1	1	2
Coating Station	1	1	2
Screen Test Stations	3	4	7
Labeling Stations	---	Marking Machine	1

ADDITIONAL TOOLING

	<u>NUMBER ADDED</u>
Carrier Trays	5,500
Transfer Racks	650
Burn-In Trays	1,600

Figure 15

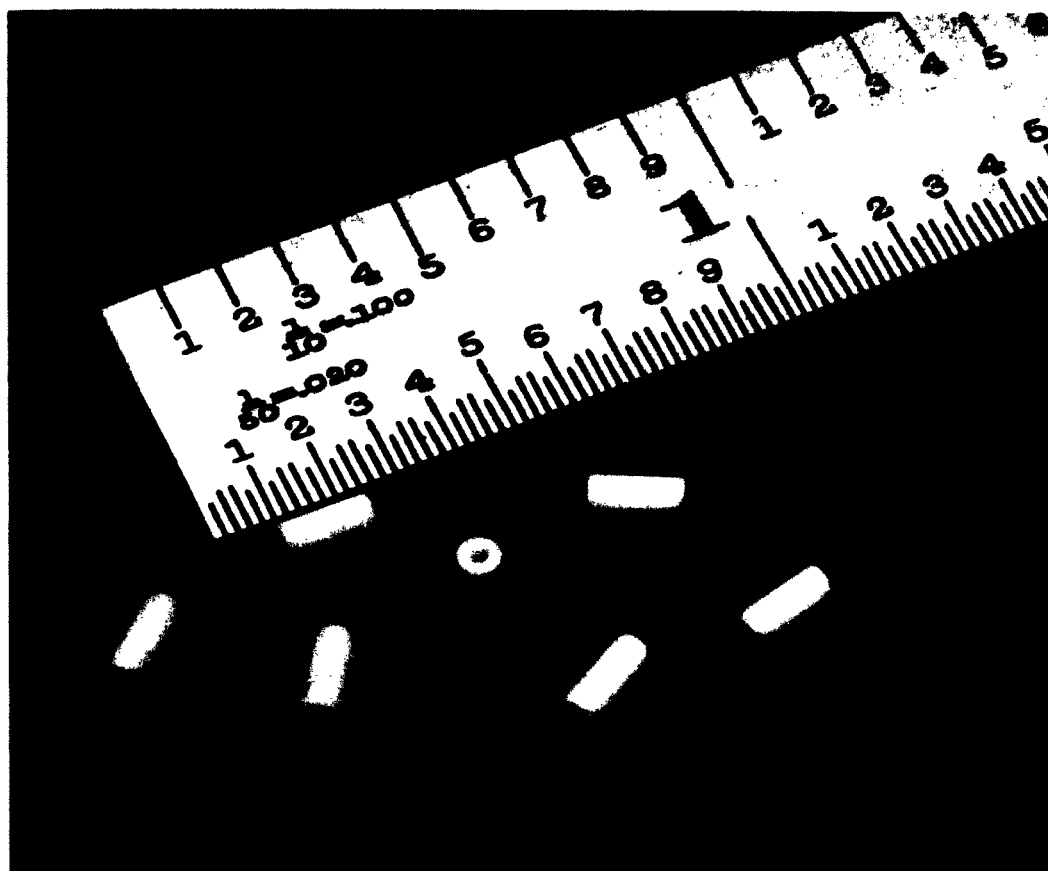


Figure 16
Ceramic Substrates

EVAPORATION DATA - CERAMIC SUBSTRATE EVALUATION

Evaporation No.	Resistance Target Ω	Resistance		Number Available 531
		531 after evaporation	614	
E 30403-21	100	86	115	400
E 30418-21	200	200	435	930
E 30409-23	700	345	620	500

Figure 17

EE-400 DIAGRAM SUB ASSEMBLY AUTOMATION

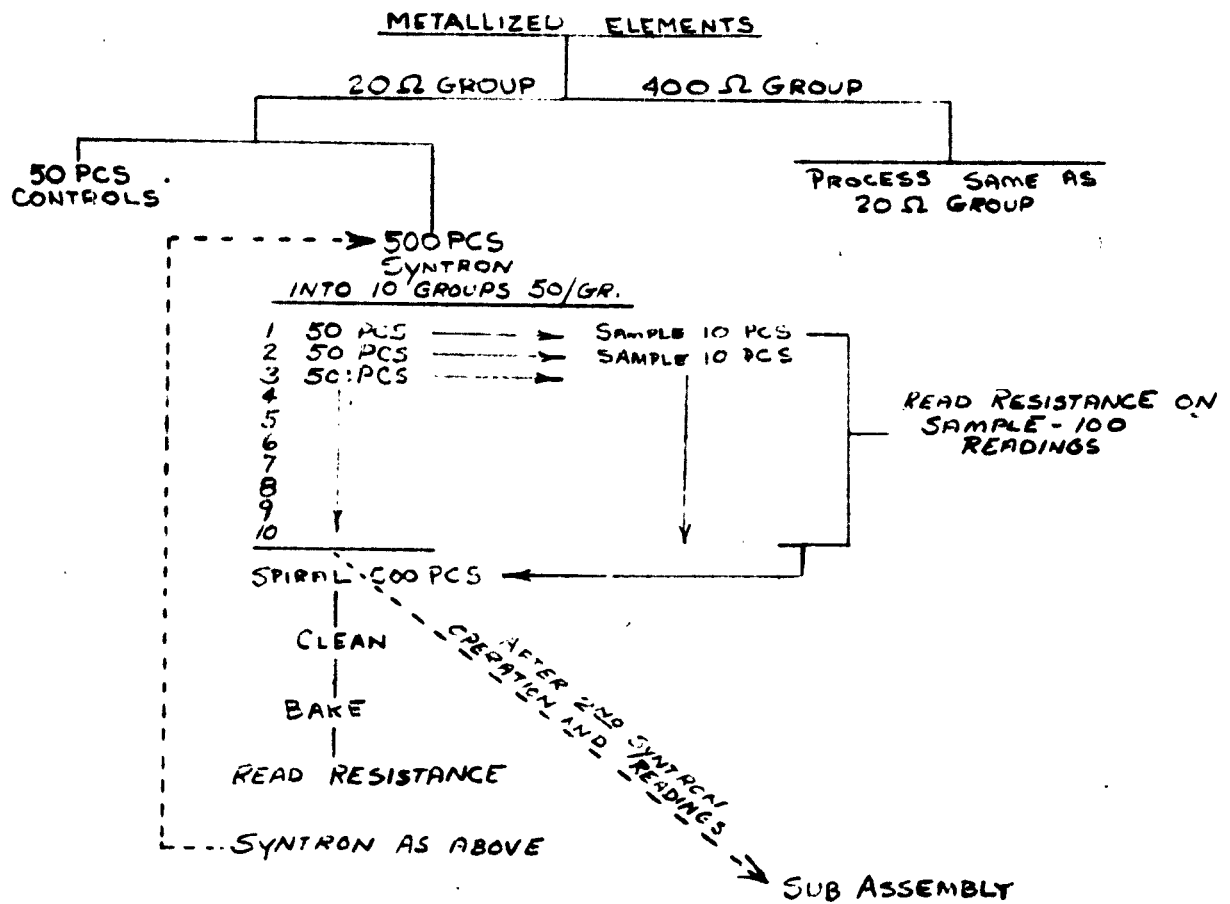
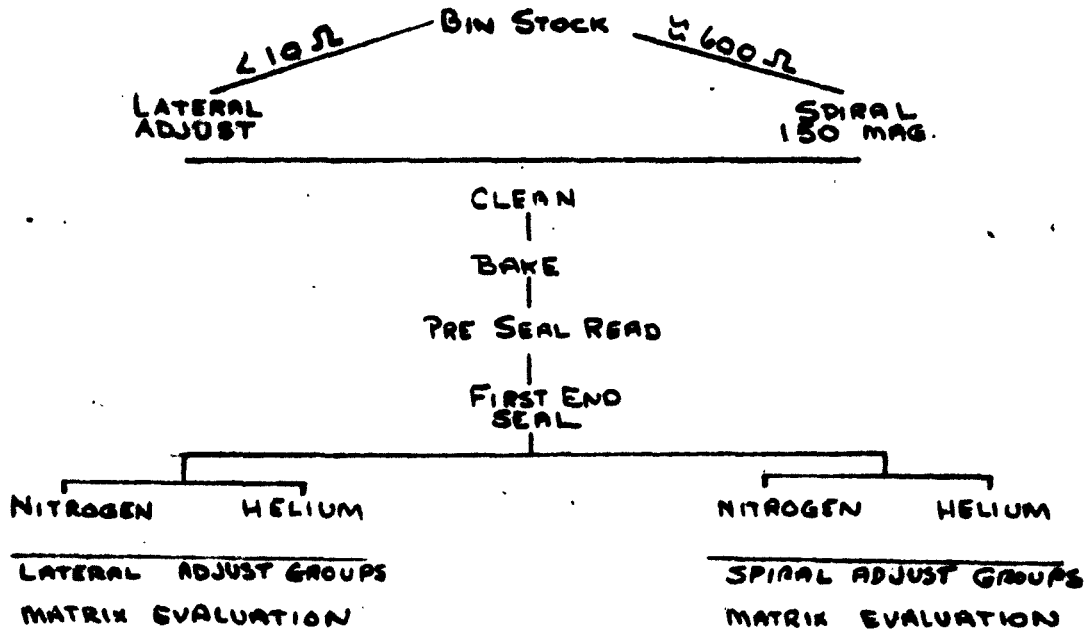


FIGURE 18

EE 401

HELIUM TO NITROGEN CONVERSION



MATRIX

TIMES OVERLOAD

		TIMES OVERLOAD		
		1X	3X	5X
25°C	NITROGEN	1X	3X	5X
	HELIUM	1X	3X	5X
125°C	NITROGEN	1X	3X	5X
	HELIUM	1X	3X	5X

FIGURE 19